

PROTECTION SWITCHING MECHANISM

Technical Field

[0001] The present invention relates generally to the field of telecommunications and in particular a system and method for protection switching.

Background

[0002] Telecommunication networks carry various types of information between users, e.g., voice, data, video. A typical telecommunications network includes many components or modules that work together to make a connection between users. For example, a telecommunications network typically includes switches, transport lines, terminals and other conventional equipment used to create transmission path connections between users.

[0003] Errors can occur in any one of these modules of the network creating a faulty transmission path. For example, a fiber optic cable that carries signals for the network can be cut inadvertently or otherwise damaged such that it cannot acceptably carry data. To prevent errors of this nature from hindering communications, networks include redundant components so that when a working component stops functioning acceptably, a redundant or protection component can be switched into the network in place of the non-working component. Thus, the network is able to continue to carry information despite errors. This is referred to in the industry as network survivability. Although, the use of redundant components has its applications, it is desired in the art to have an efficient method of routing signals dedicated to a faulty transmission path through an alternate transmission path to the desired customer.

[0004] For the reasons stated above and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the present specification, there is a need in the art for an improved method of replacing faulty transmission paths.

Summary

[0005] The above-mentioned problems with protection switching mechanisms in integrated circuits and other problems are addressed by the present invention and will be understood by reading and studying the following specification.

[0006] In one embodiment, a protection switching mechanism is disclosed. The protection switching mechanism comprises a multiplexer, a transmission path for each output of the multiplexer and a remote circuit. The multiplexer has an input coupled to receive an input signal and a plurality of outputs to output a plurality of output signals. Each transmission path is coupled to receive an associated output signal from the multiplexer. The transmission paths further include one or more redundant transmission paths, wherein signals directed to a faulty transmission path are redirected to an associated redundant transmission path. The remote circuit is used to selectively switch a redundant transmission path for a faulty transmission path at a subscriber.

[0007] In another embodiment, a protection switching transmission path device is disclosed. The protection switching transmission path device includes a central office, a remote circuit a plurality of standard transmission paths and a plurality of redundant transmission paths. The central office includes a multiplexer and a management unit. The multiplexer has an input and a plurality of outputs. The management unit is coupled to control the multiplexer. The remote circuit includes a plurality of relays and a controller card. The controller card is coupled to control the plurality of relays, wherein the control card is coupled to receive control signals from the management unit. Each standard transmission path is coupled between an output of the multiplexer and an associated relay. Each redundant transition path is coupled between an output of the multiplexer and an associated relay. Each redundant transmission path is further associated with a group of standard transmission paths, wherein if a standard transmission path in a group of transmission paths is detected as being faulty the management unit directs the multiplexer and the controller card to switch an associated redundant transmission path for the faulty standard transmission path.

coupled to an associated redundant remote unit. The management unit is used to control the output of the multiplexer and the relays, wherein when the management unit detects a line unit coupled to a faulty transmission line an output of the multiplexer assigned to the line unit coupled to the faulty transmission line is directed to an associated redundant line unit instead and a relay coupled to the faulty transmission line as well as a redundant relay associated with the redundant line unit are switched to provide an alternate signal path around the faulty transmission line.

[0010] In another embodiment, a remote circuit is disclosed, the remote circuit includes a remote shelf enclosure. The remote shelf enclosure has a plurality of remote unit slots, a protection remote unit slot, a protecting switching controller slot and a power supply module slot. A remote unit card that has a remote unit is removably coupled in each remote unit slot. A protection remote unit card that has a protection remote unit is removably coupled in the protection remote unit slot. A protection switching controller card that has a protection switching controller is removable coupled in the protecting switching controller slot. In addition, a power supply module card that has a power supply module is removably coupled in the power supply module card slot.

[0011] In another embodiment, a method of operating a transmission path network. The method comprising, grouping a plurality of transmission paths with an associated redundant transmission path. Coupling an output signal from a multiplexer addressed to a faulty transmission path in the group of transmission paths to the redundant transmission path. Coupling the redundant transmission path to replace the faulty transmission path at a subscriber.

[0012] In another embodiment, a method of switching transmission paths, the method comprising grouping a plurality of standard transmission paths in separate groups. Monitoring each standard transmission path for errors by sending a test signal from a central office to a remote circuit and back. Detecting errors in a standard transmission path in one of the standard transmission paths in a group of standard transmission paths. Outputting signals directed to the standard transmission path with errors from a multiplexer in the central office to a redundant

transmission path associated with the group of standard transmission paths instead of the standard transmission path with errors. Coupling the redundant transmission path to an end portion of the standard transmission path with errors at the remote circuit, wherein signals directed to the standard transmission path with errors are routed around the standard transmission path.

[0013] In another embodiment, a method of operating a remote shelf enclosure, the method comprising, selectively coupling a plurality of remote units in associated remote units slots. Selectively coupling a protection remote unit in a protection remote slot. Selectively coupling a protection switching controller in a protection switching controller slot. Selectively coupling a power supply module in a power supply slot. Coupling a standard transmission path to each of the remote units. Coupling a protection transmission path to the protection remote unit. Monitoring the standard transmission paths for errors. When errors are detected in a standard transmission path, switching an output of the standard transmission path with the errors for an output of protection transmission path.

Brief Description of the Drawings

[0014] The present invention can be more easily understood and further advantages and uses thereof more readily apparent, when considered in view of the description of the preferred embodiments and the following figures in which:

[0015] Figure 1 is a block diagram of an embodiment of a protection switching mechanism of the present invention;

[0016] Figure 2 is a schematic diagram of one embodiment of the switching architecture of relays of the present invention;

[0017] Figure 3 is a block diagram of an embodiment of a protection switching mechanism of the present invention;

[0018] Figure 4 is a block diagram of another embodiment of a protection switching mechanism of the present invention;

[0019] Figure 5A is a front-view of one embodiment of a remote shelf enclosure of the present invention;

[0020] Figure 5B is a back-view of one embodiment of a remote shelf enclosure of the present invention;

[0021] Figure 5C is an back-view of a portion of a terminal block of a remote shelf enclosure of one embodiment of the present invention;

[0022] Figure 5D is an back-view of a external voltage supply connection of a remote shelf enclosure of one embodiment of the present invention;

[0023] Figure 5E is an back-view of ground connections of a remote shelf enclosure of one embodiment of the present invention;

[0024] Figure 6 is a perspective front-view of a protection switching controller of one embodiment of the present invention;

[0025] Figure 7 is a flow chart illustrating one method of implementing the present invention; and

[0026] Figure 8 is a flow chart illustrating one method of switching standard transmission paths with redundant transmission paths of the present invention.

[0027] In accordance with common practice, the various described features are not drawn to scale but are drawn to emphasize specific features relevant to the present invention. Reference characters denote like elements throughout Figures and text.

Detailed Description

[0028] In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific preferred embodiments in which the inventions may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that logical, mechanical and electrical

changes may be made without departing from the spirit and scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the claims and equivalents thereof.

[0029] Embodiments of the present invention provide an efficient protection switching architecture for transmission paths. In particular, one embodiment selectively replaces a faulty transmission path from a plurality of transmission paths with a redundant transmission path. Referring to Figure 1, a protection switching mechanism 100 of one embodiment of the present invention is illustrated. As illustrated, the protection switching mechanism 100 includes a multiplexer circuit 102 and a remote circuit 104. The multiplexer circuit 102 includes a multiplexer 106. In the embodiment illustrated in Figure 1, multiplexer 106 has an input to receive a DS3 transmission path. The multiplexer 106 has a plurality of outputs coupled to DS1(1-N) transmission paths. In one embodiment the multiplexer has 28 outputs to provide 28 DS1 transmission paths from the DS3 transmission path. It will be understood in the art that although the multiplexer in the multiplexer circuit 102 is referred to as a multiplexer 106 is really a demultiplexer 106 used to separate out the multiplexed signal in the DS3 transmission path into 28 DS1 transmission paths.

[0030] Each output from the multiplexer 106 has an associated line unit (LU). In one embodiment, the line units are also located in the multiplexer circuit 102. It will be understood in the art that although Figure 1 only illustrates LU 110, 112 and 114, there would be a line unit for every output of the multiplexer 106. Each line unit provides an asynchronous DS1 interface with an associated digital subscriber line (DSL) 1-N. For example, the digital subscriber line (DSL) could be an asymmetric digital subscriber line (ADSL), a high-bit-digital subscriber line (HDSL), a high-bit-digital subscriber line 2 (HDSL2), a high-bit-digital subscriber line 4 (HDSL4) or a symmetric high-bit-digital subscriber line (G.SHDSL). The remote circuit 104 includes a remote unit (RU) 116, 118, and 120 for each line unit to convert the DSL line back to a DS1 (or T1, E1 or the like) at the customers

premise. The remote circuit 104 also includes a relay circuit 122. The relay circuit 122 contains a plurality of relays to selectively switch transmission paths. Embodiments of the present invention separate the transmission paths DS1 (1-N) into groups, wherein each group comprises a plurality of standard transmission paths and a protection (redundant transmission path). For example in one embodiment, the transmission paths are grouped into 5 normal or standard transmission paths and a protection or redundant transmission path. In one embodiment the multiplexer circuit 102 is housed in a central office 101 and the remote circuit 104 is housed at the subscribers location 103. In another embodiment, the transmission paths are bi-directional. Moreover, although not shown, it will be understood in the art that one of more repeaters may be positioned between the multiplexer circuit 102 and the remote circuit 104 to boost signal strengths.

[0031] An embodiment of a relay circuit 200 of the present invention is illustrated in Figure 2. In this embodiment, T1 transmission lines T1-1 through T1-5 are selectively coupled to a protection (or redundant) T1-6 transmission lines through relays 202, 204, 206, 208, 210 and 222. Relays 202, 204, 206, 208, 210 and 222 are positioned between a remote unit (RU) and a customer or subscriber as illustrated in Figure 2. In operation, if a transmission line has been detected as being faulty, its associated switch will be tripped to coupled the redundant protection T1-6 line to the customer instead of the faulty transmission line. For example, if transmission line T1-2 is detected as being faulty, relay 204 is tripped to connect transmission line T1-6 to the subscriber instead of T1-2. The connection to transmission line T1-6 is illustrated by the dotted lines. Moreover, when a faulty transmission line is detected, relay 222 is also tripped so the transmission line is correctly directed to replace the faulty transmission line.

[0032] Also illustrated in Figure 2, are test relays 212, 214, 216, 218 and 220. The test relays 212, 214, 216, 218 and 220 are used to test the respective transmission paths. In use, a respective relay is tripped or switched to form a closed circuit. For example, in testing T1-2 transmission line, relay 214 is switched to form a closed circuit loop. A test signal is then sent down a current path Tx (first

conductive line) of transmission line T1-2. Since the status relay 214 is tripped to form a closed loop, the signal returns back through Rx (second conductive line) of transmission line T1-2. This return signal can then be monitored for defects in the transmission line T1-2.

[0033] An illustration of how one embodiment of the present invention is controlled is illustrated in Figure 3. Figure 3 illustrates a protection switching mechanism 300 also having a multiplexer circuit 302 and a remote circuit 304. The multiplexer circuit 302 is illustrated as having a standard LU 310, which in this embodiment is a HiGain Line Unit (HLC) 310, and a redundant or protective HLU 312 produced by ADC Telecommunications Inc. The multiplexer circuit also has a management unit 308, which in this embodiment is a HiGain management unit (HMU) 308 produced by ADC Telecommunications Inc. The HMU controls multiplexer 306 as well as switching functions in the remote circuit 304. The remote circuit 304 of the protection switching mechanism 300 is illustrated as having a standard remote unit 314, which in this embodiment is a high gain remote unit (HRU) 314 and a redundant or protection HRU 316. The remote unit 304 is also illustrated as having relay circuit 318.

[0034] In the embodiment of Figure 3, multiplexer 306 implements a time slot assignment TSA in sending a signal to a specific HLU 310 during normal operations. As illustrated, a test signal from a quasi-random signal source QRSS 320 is sent through a redundant path that includes HLU 312 and HRU 316. This test signal is looped back by relay 322 through a return path through HRU 316 and HLU 312 to the multiplexer 306. This test signal continuously tests if the redundant transmission line is functional during a normal mode of operation. If a standard transmission path is detected as being faulty, the HMU directs the signal assigned to the faulty standard transmission path from an output of the multiplexer 306 to the redundant transmission path. For example, if the transmission path coupled to HLU 310 is determined to be faulty, the HMU will direct the multiplexer to output a signal originally addressed or directed to the defective standard transmission path to the redundant HLU 312. The HMU also directs the appropriate relays in the remote

circuit 304 to direct the appropriate signal to the intended subscriber line from the remote unit 304. The HMU 308 is coupled to control the relays in the relay circuit 318 through associated HLU 310, 312 and HRU 314, 316 (as illustrated by the dashed lines).

[0035] Embodiments of the HMU 308 of the present invention include a memory to store protection switching information as well as logic circuitry to perform logic functions. In one embodiment, the HMU 308 is programmed to be revertive with a switching back time. That is, in this embodiment, a transmission path that was determined to be faulty will be switched back into use when the transmission path is error free for a period determined by the switching back time. In this embodiment, a QRSS test signal is coupled to the faulty transmission path and monitored by the HMU 308 for errors. In another embodiment, the HMU is non-revertive. In yet another embodiment, the multiplexer circuit 302 includes a multiplexer memory 307 to store information that includes switching information.

[0036] As illustrated in Figure 3, the HMU 308 has a craft port 305. The craft port 305 provides a user interface to the HMU 308. In embodiments of the present invention the user interface allows a user to specify the redundant transmission paths, to specify the standard transmission paths, the switching back time as well as allowing a user to do a forced protection switching request. In addition, in some embodiments of the present invention the craft port 305 allows the user to monitor an alarm status of the line units. Moreover, in some embodiments the craft port 305 can be used by the user to preset an alarming level due to a protection switchover such as critical alarm, major alarm, minor alarm, not alarmed or not reported. Thereafter, when the HMU monitors an alarm, an appropriate alarm level will be conveyed using the predefined alarm parameters 308 set by the user. Also illustrated in Figure 3, is a TL1 port 307 and a 10 base-t interface 309 to the HMU 308, which can also be used to supply a user interface.

[0037] In one embodiment, the line units and the remote units have a high-bit-rate digital subscriber line (HDSL) version and in another embodiment the line units and the remote units have a HDSL2 version. This is illustrated in Figure 4. In

particular, Figure 4 illustrates another embodiment of the switching protection mechanism 400 with both HDSL and HDSL2 versions. As illustrated, a multiplexer circuit 406 includes a HMU 408, a line unit 410 for the HDSL2 version and a line unit 412 for the HDSL version. A remote circuit 404 includes remote unit 414 for the HDSL2 version, a remote unit 416 for the HDSL version and a protection switching card 418.

[0038] Figure 4 also illustrates, how HMU 408 communicates with the multiplexer 406 and the remote circuit 404 in one embodiment. In this embodiment, control commands from the HMU 408 are sent to the respective line unit 410 or 412 using appropriate respective protocol. The control commands are then sent down through an embedded operating channel EOC 405 or 407 to the associated remote unit 414 or 416. Thereafter, the control commands are sent to a controller card 418 in the remote circuit 404 through an associated APS bus 409 or 411. The controller card 418 in the remote circuit 404 controls a plurality of relays (an embodiment of which are illustrated in Figure 2) that control the switching at the remote circuit 404 end.

[0039] An embodiment of a remote circuit is housed in a remote shelf enclosure 500 as illustrated in Figure 5A. As illustrated, in this embodiment, a remote unit card 502 is positioned in slot 1, a remote unit card 504 is positioned in slot 2, a remote unit card 506 is positioned in slot 3, a remote unit card 508 is positioned in slot 4, a remote unit card 510 is positioned in slot 5, a protection (or redundant) remote unit card 512 is positioned in slot 6, a protection switching controller card 514 is positioned in slot 7 and a power supply module 516 is positioned in slot 8. In particular, the respective cards 502, 504, 506, 508, 510, 512, 514 and 516 are selectively coupled in their respective slot. In one embodiment, slots 1–6 are designed to hold both 4-wire HDSL or 2-wire HDSL2 remote units. The plurality of relays (an embodiment of which is illustrated in Figure 2) are located in the protection switching controller 524.

[0040] A back-view of an embodiment of the remote shelf enclosure 500 is illustrated in Figure 5B. As illustrated, wire wrap pins 518, 520, 522, 524, 526 and

528 are provided to couple a respective DS1, HDSL or HDSL2 to a respective remote unit card 502, 504, 506, 508, 510 or 512. In addition, ground connections 532 are also included as well as terminal block 534 to provide HDSL/HDSL2 and DS1 connections and an external voltage supply connection 536. For better clarification, a portion of terminal block 534 is illustrated in Figure 5C, the external voltage supply connection 536 is illustrated in Figure 5D and the ground connections are illustrated in Figure 5E. Referring back to Figure 5B, the remote shelf unit 500 further includes registered jacks (RJ)-48's 538, 540, 542, 544, 546 and 548 for slots 1-6 to provide respective DS1 connections to the subscriber.

[0041] A front-view of one embodiment of the protection switching controller card 600 is illustrated in Figure 6. The protection switching controller card 600 is used in slot 7 (514) of the remote shelf enclosure 500 of Figure 5A. In this embodiment, the protection switching controller card 600 has a LED for each slot that contains a remote unit. For example in the remote shelf enclosure 500 of Figure 5, there is an LED 602, 604, 606, 608, 610 and 612 for each slot 502, 504, 506, 508, 510 and 512 as illustrate in Figure 6. In one embodiment, the LED associated with a standard remote unit is not illuminated when no errors are detected and is illuminated with a flashing red light when errors are detected. Moreover, in one embodiment, the LED associated with a redundant or protective remote unit is not illuminated when it is being used to pass data around a faulty transmission path, is illuminated with a green light when it is ready to protect its associated standard remote units and is illuminated with a flashing red light when a fault has occurred in the redundant transmission line. In one embodiment, only one LED is on at a time to reduce power consumption.

[0042] In one embodiment of the present invention, if a protection switching controller card is not inserted in a remote shelf enclosure, the remote shelf enclosure operates in a non-protective mode. In this embodiment, a loop-back relay for protection slot 6 (512 of Figure 5A) is controlled by a special command to be either open or closed so an associated management unit MU can acknowledge the existence of the protection switching controller card. In yet another embodiment of

the present invention remote unit 510 in slot 5 in Figure 5 is also set up as a redundant remote unit 510. With this embodiment, if redundant (protective) remote unit 512 is connected to a faulty transmission line, remote unit 510 can take its place as the redundant remote unit 510. Remote unit 510 in this embodiment can be referred to as a spare remote unit 510 to provide a spare redundant transmission path. Moreover, In this embodiment both slot 5 and slot 6 will have its own automatic protection switching (APS) bus coupled to the protection controller card (slot 7) to receive control commands from a management unit.

[0043] In addition, in one embodiment, the switching controller card 514 is powered by the power supply module 516. In another embodiment, the protection switching controller card 514 receives its power from an external power source through the external voltage supply connection 536. In one embodiment, external power supply source is a -48 volt DC power source. In yet another embodiment, the protection switching controller card 514 in slot 7 of figure 5A receives its power from the redundant or protective remote unit 512 in slot 6. In this embodiment, both slot 5 and slot 6 will have a power line "OR"ed together to the protection switching controller card slot 7. This provides a backup power to the protection switching controller card if the power in protective remote unit card 512 fails.

[0044] Figure 7 is a flow chart 700 of one embodiment of a method of monitoring and replacing a standard transmission path with a redundant transmission path according to the teachings of the present invention. As illustrated in flow chart 700, the method starts at 702. Transmission paths are grouped into sub groups of standard transmission paths 704. A redundant transmission path is then assigned to each group of standard transmission paths 706. The redundant transmission path is monitored for errors 708. If an error is discovered 709, the redundant transmission is replaced 714. If no errors are detected, the standard transmission lines are monitored 710. In another embodiment of the present invention (not shown) the redundant and the standard transmission lines are monitored at the same time. If an error or errors are not detected in a standard transmission path 712 the method returns to monitor the redundant transmission path 708. If an error is detected in a

standard transmission line, the standard transmission path is replaced with the redundant transmission path 716. The redundant transmission path is then monitored for errors 708.

[0045] Referring to Figure 8, flow chart 800 illustrates replacing of a standard transmission line with a redundant transmission line in one embodiment of the present invention. As illustrated in flow chart 800, the standard transmission lines are monitored for errors 802. When no errors are detected 804, the monitoring continues 802. If an error or errors are detected in a standard transmission line 804, an output of a multiplexer directed to the faulty transmission path is switched to an associated redundant transmission path 806. Relays at a remote circuit are then switched to connect the subscriber to the redundant transmission path instead of the standard transmission path having errors 808. In another embodiment, (not shown) the outputs of the multiplexer and the relays are switched at the same time. The standard transmission path with the initial errors, in this embodiment, is then monitored 810. If the errors remain 812, the monitoring continues 810. If no more errors are detected 812, the time is monitored 814. If a select amount time has not past since the last error was detected 816, the monitoring continues 810. If, however, a select amount of time has past since the last error was detected 816, the standard transmission line is put back in service by switching the output of the multiplexer back to the standard transmission line 818 and switching the relays to connect the standard transmission line back to the subscriber 820. The standard transmission lines continue to be monitored 802.